Adaptive Control Technology

The new Exploration Vision calls for a variety of science missions ranging from Lunar/Martian exploration and habitation to extended science missions to the outer planets and their moons. Communication bandwidth constraints due to line-of-sight limitations, radiation interference and/or round trip distance makes it essential to build spacecraft systems that can independently adapt their actions in the face of poorly known environments, incompletely understood system dynamics or damage to the spacecraft. Ames Research Center has an extensive background in the design and implementation of adaptive control systems, and integration of these systems for flight missions and other control applications.

Objective

The main focus of the Adaptive Control Technologies group at NASA Ames Research Center is to develop, implement, and test next generation control architectures that enable rapid prototyping of adaptive intelligent controllers. Intelligent control architectures rely on nature-inspired, mathematically sound problem solving tools to adaptively arrive at control solutions in the midst of uncertainties and failures.

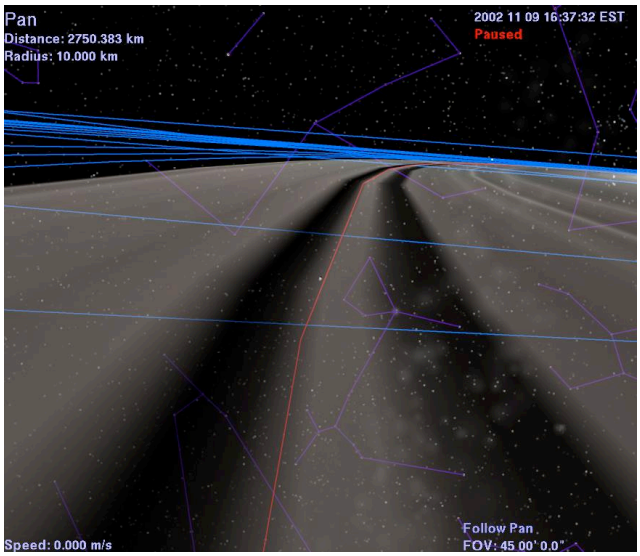
Research Overview

NASA's Ames Research Center performs research and development in a variety of key technical areas which comprise intelligent control:

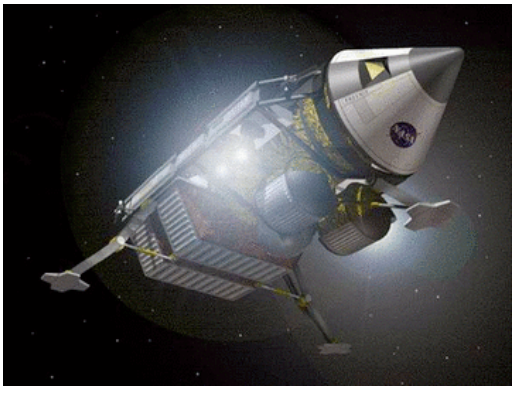
• Neural networks - These are brain inspired connectionist models that consist of many similar linear and nonlinear computational elements connected in patterns. The simple computational elements, also known as neurons, when associated in complex patterns, have the ability to perform tasks such as memory recall, pattern recognition, and learning.

• Adaptive critic architectures -- Adaptive critic designs have been defined as designs that attempt to approximate dynamic programming based on the principle of optimality. Adaptive critic designs consist of two entities, an action network that produces optimal actions and an adaptive critic that estimates the performance of the action network.

• Neural adaptive control -- The neural network based approach incorporates direct adaptive control with dynamic inversion to provide consistent handling qualities without requiring extensive gain-scheduling or explicit system identification.

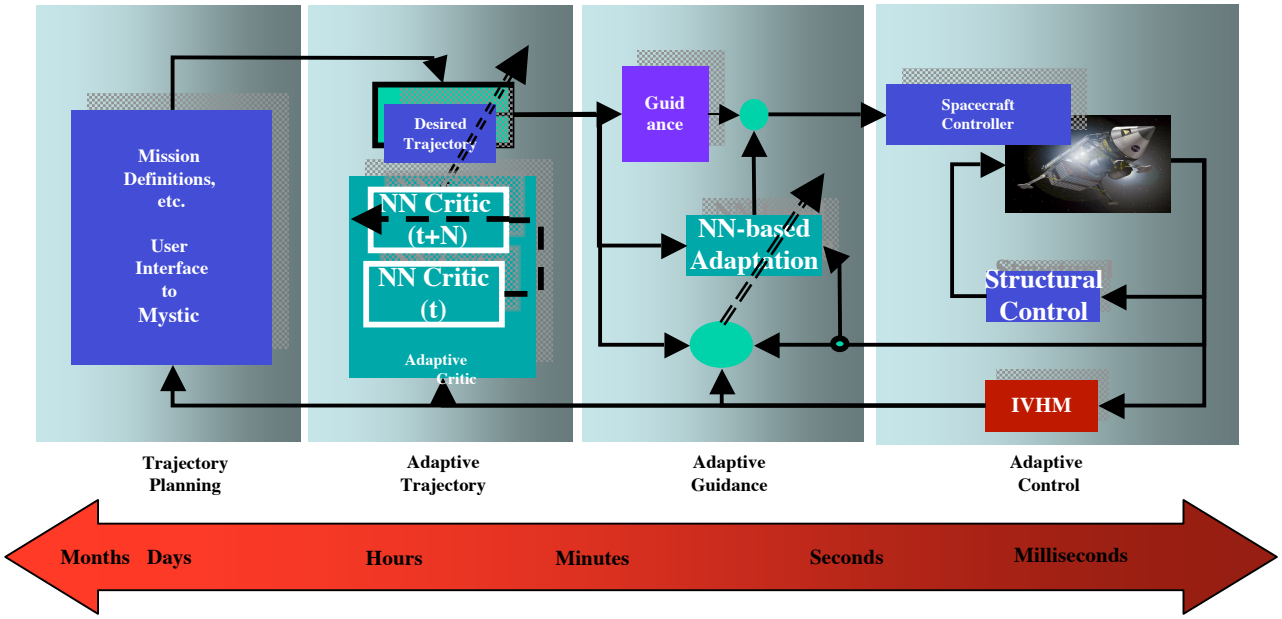


Simulation environment for computing spacecraft trajectories in the presence of complex multi-body gravitational potential fields. The simulator will be used to develop and assess adaptive trajectory techniques for returning to an assigned trajectory.

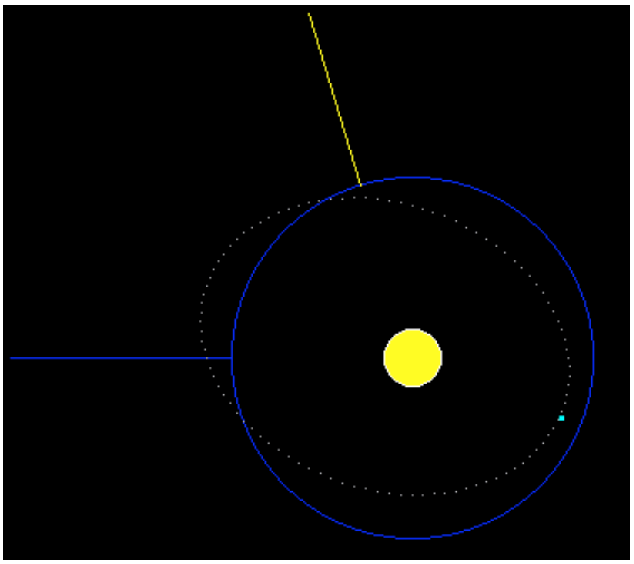


Artists concept of a future NASA spacecraft

Adaptive Control Technology



Adaptive Low Thrust Architecture: Temporal Partitioning of the Trajectory control Problem



Fixed thruster angle orbit raising for a low-thrust propulsion system around Europa under the influence of the sun (yellow vector), Jupiter and it's moons. The spacecraft's instantaneous orbital element is shown by dotted line and Europa's sphere of influence is shown by the solid blue circle. This shows the need for optimal control for stable and efficient control of low-thrust systems for orbital maneuvers in multi-body systems.

• Artificial Immune Systems (AIS) -- AIS combine a priori knowledge with the adapting capabilities of biological immune systems to provide a powerful alternative to currently available techniques for pattern recognition, modeling, design, and control.

Current applications include:

- Damage adaptive control for aircraft (i.e. F-15, C-17, B-747, Mars aircraft prototypes)
- Adaptive Low Thrust Trajectories for space trajectory applications
- Adaptive flow control for low-emission engines
- Adaptive distributed combustion control
- Intelligent control for a fly-back booster

H&RT Program Elements:

This research capability supports all H&RT program elements but is particularly relevant to:

ASTP/Software, Intelligent Systems & Modeling

Point of Contact: Kalmanje KrishnaKumar
kkumar@mail.arc.nasa.gov

Ames Research Center

NASA